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The Head-Lettuce Industry of California

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FOREWORD

Within the past 12 years the production and consumption of lettuce in the United States have been greatly increased, largely through the education of the public regarding the health-giving properties of that food.[3] Figure 1 shows the carlot shipments of lettuce

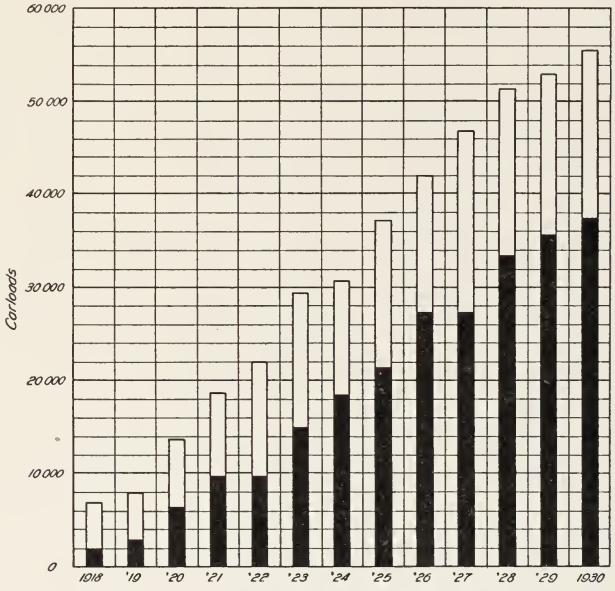

Fig. 1.—Carlot shipments of lettuce for the United States for the years 1918 to 1930. Shaded portions are California shipments.

in the United States and in California since 1917. Much of the lettuce produced near the large consuming centers is now being hauled to market by truck and therefore does not appear in these carlot totals. In 1930 over 67 per cent of all carlot movements of lettuce in the United States originated in California. During the same year this state moved as many cars of lettuce as the entire country did in 1925 and over five times as much as the entire country did in 1918.

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[3] For a detailed discussion of the economic aspects of the lettuce industry see: Wellman, H. R. Lettuce: series on California crops and prices. California Agr. Ext. Ser. Cir. 5, 1926.

TABLE 1

CARLOT MOVEMENTS AND SEASON OF SHIPMENT OF LETTUCE BY MONTHS FOR THE VARIOUS STATES, 1930*

State	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Arizona	1,695	202	2,040	2,695	6	.....	.....	.....	.....	.....	198	2,741	9,577
California, Northern District	.....	.....	2	200	108	2	10	70	48	3	511	399	1,353
California, Southern District	14	3	20	34	1	1	5	.....	.....	.....	303	598	979
California, Central District	18	.....	19	2,528	5,200	1,497	2,386	1,910	2,576	3,534	2,170	361	22,199
California, Imperial Valley	3,100	5,624	3,550	1	.....	.....	.....	.....	.....	.....	2	665	12,942
Colorado	.....	.....	.....	.....	1	97	111	759	595	45	2	.....	1,610
Florida	145	56	98	4	.....	.....	.....	.....	.....	.....	52	244	599
Idaho	.....	.....	.....	.....	3	25	.....	6	2	102	16	.....	154
Louisiana	.....	.....	.....	4	1	.....	.....	.....	.....	.....	.....	.....	5
Minnesota	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	.....	2
Missouri	.....	.....	.....	.....	8	.....	.....	.....	.....	.....	.....	.....	8
Montana	.....	.....	.....	.....	.....	1	18	.....	1	7	.....	.....	27
New Hampshire	.....	.....	.....	.....	.....	.....	.....	2	.....	.....	.....	.....	2
New Jersey	.....	.....	.....	.....	16	6	.....	.....	.....	1	4	.....	27
New Mexico	.....	.....	.....	.....	1	.....	.....	7	8	.....	.....	.....	16
New York	.....	.....	.....	.....	.....	79	1,594	985	492	69	.....	.....	3,219
North Carolina	.....	.....	.....	117	247	.....	.....	.....	.....	.....	.....	.....	364
Ohio	4	7	19	9	5	1	.....	.....	1	2	7	2	57
Oregon	.....	.....	.....	.....	7	6	1	.....	.....	.....	.....	.....	14
Pennsylvania	.....	.....	.....	.....	.....	2	2	.....	1	.....	.....	.....	5
South Carolina	.....	1	37	120	11	.....	.....	.....	.....	.....	.....	.....	169
Tennessee	.....	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	1
Texas	1	26	25	1	.....	.....	.....	.....	.....	.....	.....	.....	53
Utah	.....	.....	.....	.....	.....	8	.....	.....	.....	1	3	.....	12
Virginia, Norfolk District	.....	.....	.....	.....	14	.....	.....	.....	.....	.....	.....	.....	14
Washington	.....	.....	.....	.....	166	847	751	230	49	74	90	21	2,228
Total for United States	4,977	5,919	5,810	5,713	5,796	2,572	4,880	3,969	3,773	3,838	3,358	5,031	55,636

* Subject to revision. Data from Bureau of Agricultural Economics, United States Department of Agriculture.

TABLE 2

CARLOT MOVEMENTS AND SHIPPING SEASONS OF LETTUCE BY COUNTIES FOR CALIFORNIA, 1930*

County	Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Alameda	.....	.....	.....	10	40	3	1	.....	.....	9	3	22	88
Contra Costa	2	.....	1	4	.....	.....	.....	9	.....	.....	12	.....	28
Humboldt	.....	.....	.....	.....	.....	2	10	70	47	3	.....	.....	132
Imperial	3,100	5,624	2,677	1	.....	.....	.....	.....	.....	.....	2	666	12,070
Kern	7	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	11	18
Los Angeles	2	194	2	11	1	1	4	.....	.....	.....	315	546	1,076
Monterey	7	.....	.....	1,963	4,252	1,062	1,715	1,500	2,353	3,208	1,942	286	18,288
Orange	.....	.....	.....	1	.....	.....	.....	.....	.....	.....	.....	.....	1
Riverside	10	3	7	2	.....	.....	.....	.....	.....	.....	.....	.....	22
Sacramento	.....	.....	.....	162	93	.....	.....	.....	1	.....	264	232	752
San Benito	.....	.....	.....	7	48	.....	.....	.....	15	127	40	.....	237
San Diego	2	.....	.....	14	.....	.....	1	.....	.....	.....	.....	25	42
San Joaquin	.....	.....	1	3	.....	.....	.....	.....	.....	.....	25	39	60
San Luis Obispo	.....	.....	.....	104	111	20	4	2	1	2	1	.....	245
San Mateo	.....	.....	.....	.....	3	8	22	17	9	.....	.....	.....	59
Santa Barbara	.....	.....	12	220	207	199	376	228	41	31	32	15	1,361
Santa Clara	.....	.....	.....	28	59	36	31	.....	6	1	2	.....	163
Santa Cruz	.....	.....	.....	186	418	168	236	136	87	147	122	14	1,514
Solano	.....	.....	.....	18	.....	.....	.....	.....	.....	.....	67	57	142
Stanislaus	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....	2	2
Tulare	.....	.....	.....	6	.....	.....	.....	.....	.....	.....	.....	22	28
Ventura	.....	.....	4	3	.....	.....	.....	.....	.....	.....	.....	.....	7
Yolo	.....	.....	2	17	14	.....	.....	.....	.....	.....	103	60	196
Total	3,130	5,821	2,706	2,760	5,246	1,499	2,400	1,962	2,560	3,528	2,930	1,997	36,539

* Data from Bureau of Agricultural Economics, United States Department of Agriculture.

PRODUCTION AREAS IN THE UNITED STATES

Production areas of more or less importance are scattered throughout the entire country. The New York variety is raised mainly in the irrigated regions of the West, the most extensive areas being located in Arizona, California, Colorado, Idaho, and Washington. At present certain strains of New York are being grown successfully in the East, but they are not yet cultivated there extensively. The variety Big Boston is grown in the Middle West, East, and South, particularly in New York, North Carolina, South Carolina, and Florida.

Table 1 gives the carlot shipments of lettuce by states for the year 1930. Although the shipping season of each locality varies slightly from year to year with seasonal conditions, the table, nevertheless, gives the approximate time when lettuce may be expected to move from the different districts.

PRODUCTION AREAS IN CALIFORNIA

The two main lettuce-producing areas of California are the Imperial Valley and the Salinas-Watsonville district, comprising the lower Salinas and Pajaro valleys. A number of other districts, however, are located along the coast and in the interior valleys. Their relative importance is shown in table 2, which gives the carlot shipments of lettuce by counties for the different months.

Shipping Seasons for California Lettuce.—Lettuce moves from California in quantity all the year around. In 1930 the lightest shipments were in June, with a total of 1499 cars. From the Imperial Valley the lettuce movement is mainly during December to March; in the Salinas Valley, from April to November, with the spring peak coming in May and the fall peak in October.

Distribution of California Lettuce.—California lettuce is widely distributed throughout the United States and Canada during the entire year. Most of it is shipped in carlots, but some is moved in mixed cars. A considerable quantity, in addition, is moved to nearby markets by truck, without ice in the containers.

CLIMATIC AND SOIL REQUIREMENTS

Lettuce of high quality can be produced only where the temperature of the soil and air is moderately cool and uniform while the crop is maturing. This requirement must be kept in mind, especially by those who are attempting to mature lettuce during the summer. Fluctuating high and low temperatures are not conducive to good growth. High temperatures favor the production of seed stems, cause a bitter taste in the leaves, produce loose heads, and accelerate the development of lettuce diseases. During the early stages of development, lettuce will tolerate a considerable amount of frost; but, if severely frosted when mature or nearly mature, it is more subject to slime and therefore does not ship well. Generally, frosted lettuce needs close trimming and is therefore not attractive. The maturing plants make very little growth during continued frosty weather: although the heads may become solid, they remain small, their leaf tips are injured, and the trade considers them undesirable.

Lettuce must have an adequate supply of moisture throughout the growing season. An excessive amount of water in the soil is, however, not desirable; and too much fluctuation in soil moisture may cause the production of small, loose heads.

Lettuce is grown successfully on a wide variety of soil types ranging from clay loams to sandy loams and muck, but it attains its highest quality on fertile loam soils rich in organic matter. Where the fall crop is subject to high temperatures during its early development or where it matures during warm weather, the heavier types of soil should be used, for they hold more moisture and are cooler. The lighter, well-drained soils may be used to produce the crop that is planted and grows during the cool season of the year. Because the adobe soils cannot be worked soon after a heavy rain, a definite planting schedule cannot easily be followed where rainfall is heavy during the period of preparation and planting. All lettuce land should be well drained and properly leveled for irrigation.

MAINTAINING SOIL FERTILITY

About 80 to 85 per cent of the lettuce crop is grown by large operators, who lease the land for periods of one to five years. When the lease expires growers often find it more profitable to lease new land that has been in alfalfa or other crops for a number of years, than to continue to plant on a soil that shows declining yields.

The soil problems involved in lettuce growing are chiefly those of maintaining a good soil in a highly productive state. Where good lettuce land is almost unlimited, as in the Imperial Valley and north-central districts of California, this problem is not so difficult. In the central-coast district of the Salinas-Watsonville area, ideal conditions prevail for growing of summer lettuce but the area of land is limited. Here the only possible procedure is to plant the same soils to lettuce year after year.

Crop Rotation.—Although as many as five or six crops of good lettuce have been grown consecutively, usually no more than two are profitable without some sort of rotation, because various lettuce diseases accumulate in the soil and infect succeeding crops.

In the Imperial Valley, alfalfa is commonly used in the rotation. Lettuce is often planted directly on alfalfa sod, but more often cantaloupes or some similar cultivated crop is grown first. As a rule it is difficult to make a good lettuce seed bed and to control weeds immediately after alfalfa. Lettuce growers of the Imperial Valley follow no one system of rotation. Sometimes an early crop of lettuce and a late crop of cantaloupes are grown the same year. After being in cultivated crops for three or four years, the land is, as a rule, resown to alfalfa. A deep-rooted legume crop followed by a series of shallow-rooted nonlegume crops makes a good rotation.

In the San Fernando Valley, lettuce is grown very commonly as an intercrop among deciduous fruit and English walnut trees, as shown in figure 2. It is planted in the fall when the trees are bare, so that extreme shading does not occur. Spring lettuce is also grown after fall crops of cauliflower, tomatoes, celery, or fall lettuce. Fall lettuce often follows spring potatoes. For the fall crop, seed is sown in August or September; for the spring crop, in November, December, or January. In Los Angeles County, where land is high-priced, it must be kept occupied with highly profitable crops.

In the Salinas-Watsonville district the growing of two or more crops on the same soil in a year is now an established practice. This

district is very fortunate because a large number of crops can be grown profitably in rotation with lettuce. It is possible to work out a rotation with lettuce planted for harvesting any time of the year.

Certain crops are harvested immature, require frequent irrigation, and leave the soil moist at harvest time; examples of these are lettuce, spinach, green peas, cauliflower, cabbage, broccoli, Brussels sprouts, endive, carrots, and celery. These should be rotated with crops that are harvested mature, that require less frequent irrigation, that leave

Fig. 2.—Lettuce growing between English walnut trees in Los Angeles County. (From Circ. 295.)

the soil dry at harvest time—such as dry beans, sugar beets, fall potatoes, onions, garlic, tomatoes, barley, wheat and vetch, garden pea seed, and sweet pea seed.

The following crops can be grown for spring harvest and still allow sufficient time to mature a crop of lettuce during the summer or fall: lettuce, garden peas, carrots, spinach, sugar beets, sweet pea seed, onions, garlic, green peas, vetch seed, wheat, and barley. The following crops can be grown for fall harvest: lettuce, green peas, sugar beets, tomatoes, potatoes, carrots, cauliflower, spinach, and celery.

Though there are a large number of crop rotation systems, the individual must determine the exact procedure to meet his particular needs. A few suggestions, however, may serve as a guide. One plan is to alternate two crops of lettuce with one rotation crop, an arrange-

ment whereby lettuce can be grown on two-thirds of the available acreage. Another plan now being practiced successfully by a few lettuce growers is to carry out the above rotation, but in addition to keep one-fourth of the land in alfalfa for three to four years. Alfalfa, however, does not fit well into the general lettuce-farming plan in the Salinas-Watsonville district and can be grown profitably only by those who have means of marketing or using the hay. Lettuce growing in conjunction with dairying and alfalfa growing is an ideal combination but one which, unfortunately, is practiced to only a limited extent.

The refuse of all crops, such as straw, stalks, or unharvested plants, adds organic matter and should therefore be returned to the soil. If large amounts of straw or similar material are turned under, commercial fertilizers are usually needed to offset temporary decreased fertility during decomposition.

With 80 to 85 per cent of the California lettuce grown on leased land, the establishment of crop rotation as a practice is not alone the problem of the grower and shipper, but also that of the landowner. As rentals are based mainly on the ability of the land to produce marketable lettuce, landowners who wish continuously to enjoy a satisfactory income from their land obviously must use farming practices that will keep their soil highly productive.

A lease should not dictate just what crops are to be grown; but it might be well to stipulate in the lease the number of crops of a single commodity to be grown in succession on the same soil, the disposition of crop by-products having fertilizer value, and other similar conditions of soil management.

Need for Organic Matter.—Active organic matter in the soil is essential to lettuce production. This term is applied to organic material which is decomposing and is capable of sustaining bacterial life. The amount required varies with the soil type. Sandy and porous soils usually have a very high rate of decomposition and become depleted much faster than the heavy soils. If sufficient active organic matter is maintained, additional fertilizing may not be required.

Organic matter in the soil may become inactive through constant wetting or from cultural practices used in connection with growing a specific crop. A crop rotation that allows moderate drying and airing of the soil appears to stimulate decomposition of organic matter which has become inactive. Organic matter lightens the heavier soils, thereby improving aeration and water penetration. It is usually supplied to the soil in the form of barnyard or other types of manure or by the growing of green manure crops.

Manures.—Probably the best fertilizer for lettuce is barnyard or other types of animal manure. If they are well pulverized, the manures are usually applied and worked into the soil just before the beds are listed. Fresh and coarse manure should usually be composted before being applied to the land, especially if lettuce is to be planted immediately. In composted manure, more of the plant food elements are in an available form, there is no coarse material to interfere with planting and cultivation, many of the noxious weed seeds have been destroyed, and there is no heating of the soil. In composting, however, one should try to prevent leaching of the soluble salts and the loss of ammonia by heating. Fresh or unrotted manure, if used, should be plowed or disked under in time to decompose partially before the crop is planted, or should be used in light applications. Decomposition of the manure after it has been plowed under may be accelerated by flooding the land. In tests conducted in the Imperial Valley, an application of 10 tons of barnyard manure to the acre increased the total yield 54 per cent, caused the lettuce to mature two to four weeks earlier, and resulted in the production of larger heads, better in quality, than the adjoining unmanured plots. Applications of manure on land in the Salinas Valley and other districts have produced a striking response. Excessive applications, however, especially in warm weather, often cause the formation of loose heads.

Green Manure Crops.—Where manure cannot be obtained in sufficient amounts to supply the needed organic matter and plant food, green manure crops, alone or in conjunction with commercial fertilizers, may be used. To grow green manure crops is better than to let the fields lie idle during a part of the year. Such crops keep down the weeds, add to the total organic content, and help conserve the soluble mineral elements of the soil, especially in regions of heavy winter rainfall. They prevent erosion, help aerate the subsoil, and increase the favorable bacterial flora of the soil. They improve the texture of sandy soils and to some extent increase their moisture-holding capacity.

The covercrop, or the green manure crop (preferably a legume) that is chosen, should be adapted to the local climatic conditions and should produce a good tonnage of vegetable matter. The choice of a crop will depend upon the planting time and the growing season. Usually a thorough disking is given before the green manure crops are plowed under. If the soil is dry, irrigation after plowing will hasten decomposition. This must be fairly complete before the next crop is planted; otherwise, injurious results may follow.

In the Salinas-Watsonville district, green manure crops, such as vetch or *Melilotus indica,* are planted in early fall after the lettuce has been harvested. One must usually irrigate the land to germinate the seed; thereafter, the winter rains are sufficient to mature the crop. The following spring, the growth is disked and plowed under. Garden peas are also used extensively for green manure purposes, the vines being turned under as soon as the crop has been picked.

In the Imperial Valley, alfalfa is used rather often in the rotation. Green manure crops are also employed to supply the necessary organic matter. In one small test, Hubam clover appeared to offer promise as a spring covercrop. When planted from March 15 to April 10, it can

Fig. 3.—Brabham cowpeas in Imperial Valley. This crop will yield about 24 tons of green tops to the acre. It is resistant to the attacks of nematodes. (From Cir. 295.)

be plowed under late in June. Brabham cowpeas (fig. 3) and Laredo soybeans have been shown to be good summer green manure crops: they produce a heavy growth and are resistant to nematode attack. They are usually planted from April 15 to May 15 and require about 80 days to mature. Guar is another heavy-producing, summer-growing, nematode-resistant legume. It is planted in June and requires about 100 days to mature. The green manure crop now used in Imperial Valley almost to the exclusion of all others is the common legume *Sesbania macrocarpa.* In trials at the Meloland Field Station, a red-stemmed species, *Sesbania cannabina,* appears to offer equal if not greater promise. Sesbania is usually broadcast at the rate of 40 to 60 pounds of seed per acre, between May 15 and July 15, on land prepared flat for flood irrigation. It produces a crop that can be plowed under in 40 to 60 days.

The advantages of sesbania are its suitability to Imperial Valley conditions, its rapidity of growth, its cheapness of production, its adaptability to flood irrigation, and its rapid decay. It outgrows most weeds. Most of the other summer crops, such as cowpeas, soybeans, and guar, grow more slowly and require cultivation to keep down the weeds. One 40-acre planting of sesbania in Imperial Valley in 1931 cost $5.38 per acre up to the time that it was plowed under. Sesbania is plowed under without being disked previously. Notched disk plows are commonly used to turn the rank growth under. The growing of truck crops in beds and the "subbing" of the moisture to the plants

Fig. 4.—Plowing under sesbania in the Imperial Valley. Notches in the disk are for catching and turning under the sesbania stalks. (Courtesy, F. G. Beyschlag.)

tend to accumulate salts in the ridges. The flood irrigation required in growing the sesbania counteracts this tendency by leaching the salts to lower levels in the soil. Sesbania planted early in the season, plowed under in July or August, and then irrigated, is practically all decayed by the time lettuce is planted in October.

Sesbania also has certain disadvantages. It is susceptible to nematodes, requires high temperatures, an abundance of water, and does not produce quite so much dry organic matter per acre as the other summer legumes mentioned above. It may also serve as a breeding ground for alfalfa caterpillars and cucumber beetles. Lettuce, however, being grown during the cool season of the year, suffers very little from nematode attacks. The insects, particularly the alfalfa caterpillars, can be prevented from spreading to adjoining fields if the

sesbania is plowed under at a medium stage of maturity, before it attains its full growth. The ease and cheapness of growing sesbania may overbalance its lower production of dry organic matter.

Commercial Fertilizers.—Some growers plant green manure crops and in addition use commercial fertilizers to keep the soil in a state of high productivity. The three constituents supplied in a complete fertilizer are nitrogen, phosphorous, and potassium. Any one or all of these may be supplied in the organic or inorganic form. In the latter, the elements are immediately available to the plant, while in the organic form, the complex compounds must undergo decomposition into more simple forms before they can be absorbed by the plant. This decomposition or change is effected by different bacterial groups in the soil. When the temperature of the soil is low, these bacteria function slowly or not at all; so it is better, during the cooler season at least, to apply the fertilizers in the inorganic form.

No single kind or uniform amount of fertilizer can be specified for the entire state or for any large district within the state. Each grower should make a number of tests on his own farm to determine the kind of fertilizers to use and the most profitable amount to apply. In general, lack of nitrogen is usually what limits the growth of the lettuce plant. Nitrogen can be applied in the inorganic form as nitrate of soda, sulfate of ammonia, or calcium nitrate; or in the organic form in such compounds as tankage, fish meal, cottonseed meal, and dried blood. A complete fertilizer is often broadcast, or drilled in after plowing and before the beds are made, but may be drilled in the center or in the sides of the bed before the seed is planted. Some growers drill the fertilizer one or two inches below the seeds at the time of planting, by use of special attachments on the seeders. Inorganic nitrates may be applied immediately after the plants have been thinned and until about a month before harvest. Their application just after thinning and before the next irrigation, is usually to be recommended. In the Imperial Valley, a side dressing, after thinning, of 200 to 300 pounds of nitrate of soda per acre is the general practice. Often there is a second application of 150 to 200 pounds to the acre. In the Los Angeles district nitrogenous fertilizers seem to be the only kind needed. They may be drilled in along the side of the bed, as shown in figure 5, or spread in the furrows before irrigations. One should usually not apply large amounts of nitrogen after the heads have started to form. The use of inorganic nitrogenous fertilizers should be so timed as to produce a good growth before the heading period. Too much available nitrogen at heading time may cause the production of large, soft heads. Many of the soils of the state respond

more definitely to the addition to organic matter than to commercial fertilizers. Even the nitrates cannot always be depended upon for the desired results.

Some of the large growers in the Imperial Valley are now using 200 pounds per acre of treble superphosphate, analyzing 46 per cent phosphorous pentoxide (P_2O_5). Heavier applications have, in many cases, given even better results. This phosphate is broadcast on the ground before the beds are listed or on the plowed sesbania ground before it is disked and floated.

Fig. 5.—One type of drill used to apply fertilizer to the sides of the lettuce beds. A plumber's "Y" of two-inch pipe is fastened to the frame underneath the fertilizer hopper of an ordinary combination corn planter and fertilizer drill. This device facilitates a uniform distribution of the fertilizer along the sides of the bed. (From Cir. 295.)

PREPARATION OF LAND PREVIOUS TO PLANTING

Leveling.—In the growing of lettuce under irrigation the land must be level (fig. 6) and the beds of uniform height so that water can be applied without flooding certain areas and leaving others high and dry. Any leveling necessary should be done well in advance of the planting season. If much soil has to be moved, a test irrigation had best be made in order to settle it and to reveal the depressions and elevations. The necessary retouching can be done after the soil has become sufficiently dry. After leveling, manure or a commercial fertilizer is often added to the places where the top soil has been removed, so that a satisfactory crop will be produced.

Preparatory Tillage.—In general, the soil should be plowed and then disked and harrowed to a fine, mellow condition before the seed beds are made. To make good beds or do good seeding on a cloddy soil is difficult. When seeding is done during very hot weather, however, aeration is facilitated and better stands are obtained if the soil is left a little crumbly.

When alfalfa land in the Imperial Valley is broken up for lettuce, it is given a deep plowing several months in advance and left in a rough condition until about a month before planting. The land is next floated, replowed, again floated, and then given a quick irrigation. Sufficient time should be allowed after the first plowing to kill the

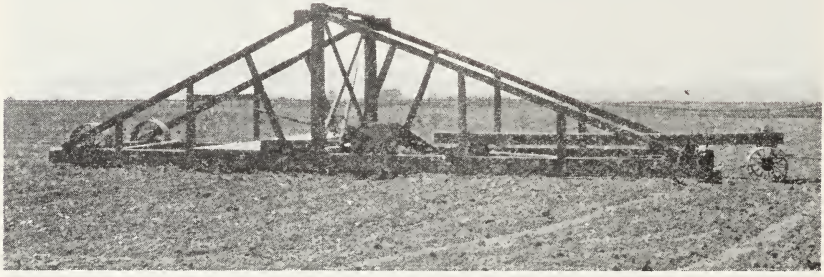

Fig. 6.—A float used in leveling lettuce land in the Salinas Valley.

Bermuda grass and alfalfa, and sufficient time after the second plowing to float, border, flood, dry out the soil, disk, float, and make seed beds in advance of the desired planting date. A common sequence of operations for land that has just grown a cultivated crop is plowing about eight inches deep, double disking and floating, and then replowing, disking, cross-disking, floating, and bedding. In some districts more operations may be necessary, the method of handling depending a great deal on the type of soil. Chisel cultivators, adobe harrows, and ring rollers are sometimes used in heavy soils.

Planting Practices.—Three general planting practices are employed in growing lettuce in California. The crop may be seeded on level ground, on raised beds in dry soil, or on raised beds in moist soil. Planting without beds is used only in a limited way in certain coastal valleys where rain is the only source of moisture available. Under those conditions seeding is done in rows 20 to 24 inches apart after the first rains in the fall, and harvest is in the early spring.

Almost all the lettuce in California is planted on raised beds, which facilitate irrigation and drainage and give good aeration about the plants. The general custom is to grow two rows on a bed.

Making the Beds.—The width of bed, distance between beds, and depth of furrow vary in different regions, according to the climatic conditions and type of soil. The beds are 18 to 20 inches or more in width, and the furrows 18 to 22 inches or more (fig. 8). Seldom are the beds less than 3 feet from center to center, and usually they are

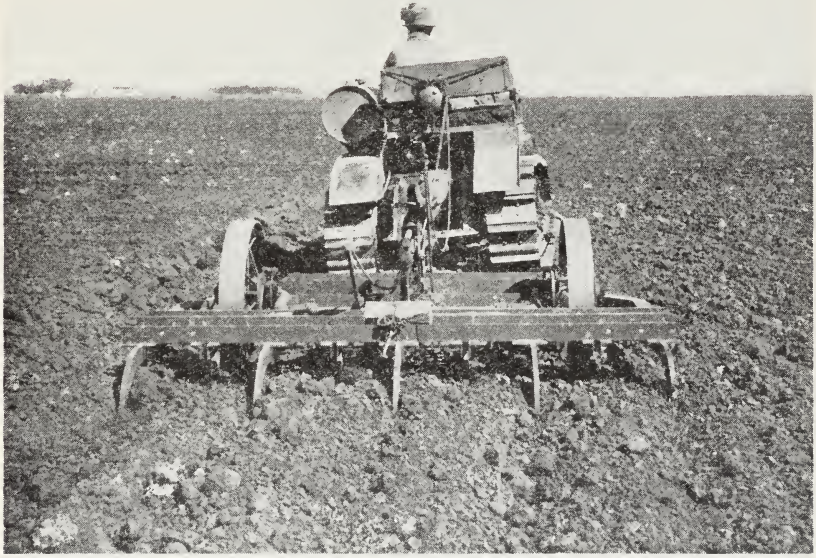

Fig. 7.—Preparing the soil in the Salinas Valley for the fall crop of lettuce after harvest of the spring crop. The land is first disked and then either plowed or deep-cultivated, as shown above, to loosen the soil before the beds are made.

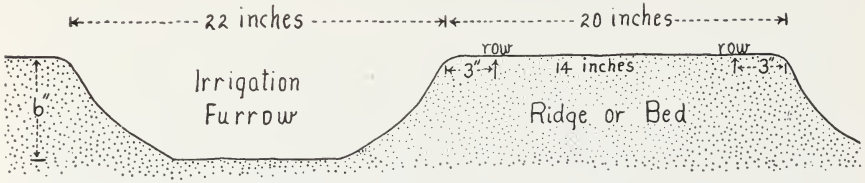

Fig. 8.—General type of bed and furrow used in the growing of lettuce in California. Dimensions vary according to local conditions. (From Cir. 295.)

still farther apart. They should be 4 to 10 inches high after smoothing. If the furrows are not sufficiently deep, there is danger of flooding the beds. Inexperienced growers, as a rule, have a tendency to make them too shallow.

The rough beds are made with a single lister pulled by two horses, or with a double or triple lister pulled by a tractor, as shown in figures

9 and 10. The rough beds may be shaped with a harrow or sled just before seeding or with the planter sled at time of seeding. For very hard and cloddy soil, special equipment must often be devised to pulverize the beds so that they can be seeded.

Fig. 9.—Making lettuce ridges with single and double listers. (From Cir. 295.)

Fig. 10.—Making lettuce beds for a fall crop in the Salinas Valley with a triple lister. The beds are irrigated before seeding.

VARIETIES AND STRAINS

The only variety of lettuce grown for commercial shipment in California is the New York, known to the trade as "Iceberg." The true Iceburg variety, however, although similar to New York in habit of growth, has leaves of a reddish tinge.

No less than ten different strains of New York lettuce are now being offered for sale, and new ones are constantly being added (fig.

Fig. 11.—A specimen of New York lettuce, the only variety shipped from California in quantity. (From Cir. 295.)

11). Though all these strains have certain desirable characteristics, they do not all thrive equally well under the same set of conditions, and the grower often has difficulty in selecting the best strain for his particular conditions.

The commercial New York strains can be grouped into three general classes, based on disease resistance: (1) those susceptible to mildew and brown blight; (2) those resistant only to brown blight, or "single resistant"; and (3) those resistant to both mildew and brown blight, or "double resistant." All the resistant strains are designated

by the name Imperial; numbers indicate the single-resistant and letters the double resistant types.

Strains Susceptible to Mildew and Brown Blight.—New York Regular: For many years what was generally known as New York Regular or New York Special was the only seed planted. It has been improved from year to year and under favorable conditions produces a high percentage of uniform, good-quality heads. It is grown to some extent in all districts where the soil is not infected with brown blight.

New York No. 12: This, a selection out of New York Regular, is an early low-heading strain, slightly lighter in color than New York Regular. It is very uniform in appearance and in time of heading. The head is exposed, as there are very few wrapper leaves. It heads well during warm weather and stands considerable heat. Although not so subject to tipburn and slime as some other strains, it is by no means immune. No. 12 has been a great favorite with growers during the last few years.

New York No. 41: This, a selection out of New York Regular, has an abundance of wrapper leaves of a deep green color. In early growth, the head formation is well covered and has a pointed appearance. It requires a few days longer to mature than No. 12, and it yields best if matured during the winter and for the main spring and fall crops.

Strains Resistant to Brown Blight.—These strains and those of the following group have been developed mainly by Dr. I. C. Jagger of the United States Department of Agriculture.

Imperial No. 2: One of the first strains developed for resistance to brown blight was Imperial No. 2. This strain has produced satisfactory yields in the Imperial Valley, but not along the coast. It is very irregular in heading and will not stand warm weather.

Imperial No. 3: This strain, which is slightly larger than Imperial No. 2, has a tendency to be puffy. Satisfactory yields have been obtained in the Imperial Valley, but not under warm weather conditions. It is very little grown at the present, even in Imperial Valley.

Imperial No. 6: The outer leaves of this strain tend to spread and to grow close to the ground, exposing the head. It has a dark green color and it matures late. Like Imperial No. 2 and No. 3, it heads best under winter conditions. A few excellent crops have been produced on the coast in the early spring and late fall, but in general it does not produce satisfactorily under warm conditions.

The above strains of Imperial are distinct lines, having originated from three individual parent plants.

Imperial No. 2–50: This, a selection out of Imperial No. 2, is very uniform in size and heading characteristics, has given good results in the Imperial Valley for winter harvest and on the coast for early spring and late fall harvest. Like the other single resistant strains, it will not stand high temperatures and should not be planted for harvest during warm weather.

Strains Resistant to Both Mildew and Brown Blight.—These strains, which are double-resistant, are designated by letters.

Imperial C: This is a black-seeded strain, 100 per cent resistant to both brown blight and mildew; it attains good size but will not stand warm weather.

Imperial F: This strain is slightly smaller than C but more uniform in heading; it stands warm weather better than any of the other resistant strains, enduring heat as well as New York Regular and possibly as well as No. 12. Satisfactory yields have been obtained under late spring conditions in the Salinas-Watsonville district. Imperial F is very similar to New York Regular in type and soil and climatic adaptations.

Imperial D: This is one of the latest double-resistant strains still being tested in an experimental way. It is dark green in color, large, and very firm. The texture is rather coarse.

TIME OF PLANTING

Lettuce requires from 70 to 150 days to mature, according to soil and climatic conditions. The longest time is required for lettuce planted in early winter; and the shortest time for plantings made for late summer or early fall harvest.

In the Imperial Valley, seeding is done during the fall, and harvest takes place in the winter. During the remainder of the year the land is used for other crops.

In the interior valleys and south coastal districts an early spring and a late fall crop is possible; the spring crop being planted during the winter months and the fall crop in late summer.

In the Salinas-Watsonville district, where cool, foggy conditions prevail during the summer, lettuce can be successfully matured during any time of the year except from late December to the latter part of March. In this district three crops of lettuce can be matured on the same land in a single year; usually, however, only two crops are grown.

SOWING THE SEED

Various tools have been devised for sowing. The two rows on top of the bed may be sown in a single operation by implements similar to those shown in figures 12 and 13, but a gang of four planters can be used if the two beds have been made at the same time, as shown in figure 14. This system spaces the rows evenly and thereby facilitates cultivation on top of and between the beds.

Fig. 12.—Planting two rows at one time. Sleds should be designed to smooth the top of the bed, to firm the soil so as to provide a good seed bed, and to carry the seed drills so that the seed is planted at a uniform depth, and at a uniform distance from the center of the furrow. (From Cir. 295.)

Lettuce seed, being very small, should be sown shallow, but sufficiently deep to be in contact with moisture. It will not germinate at high temperatures unless the soil is well aerated. During warm weather this aeration is accomplished by leaving the seed bed slightly coarser than during the cool season of the year. According to Borthwick and Robbins,[4] if lettuce seed is to be planted in a soil which has a temperature of 86° Fahrenheit or more during many hours of the day, good germination can be obtained by placing the seed in thin layers between moist burlap and then storing on ice for four to six days. Good aeration must be provided during this storage period. When the seed is dried and planted in moist soil, a high percentage of germination is obtained.

[4] Borthwick, H. A., and W. W. Robbins. Lettuce seed and its germination. Hilgardia 3:275–304. 1928.

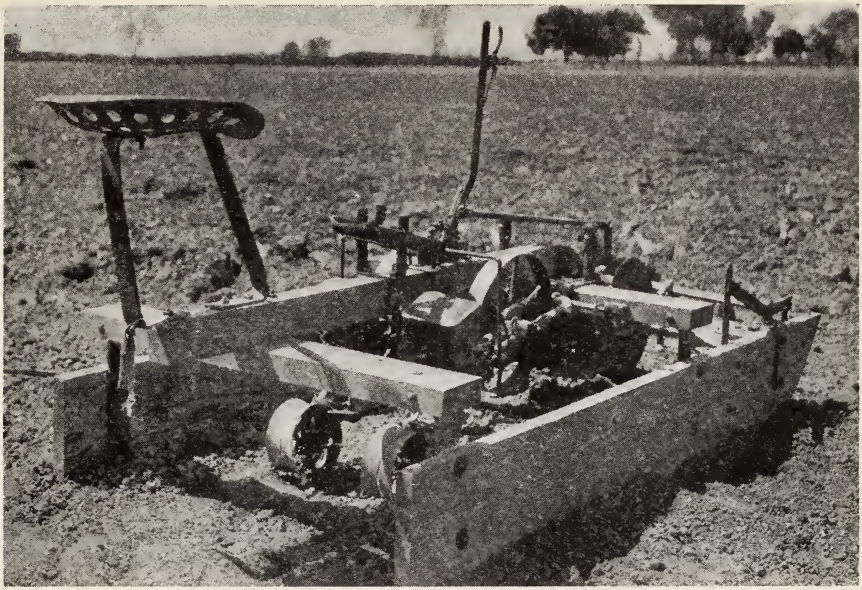

Fig. 13.—Two-row lettuce planting sled. Note the four rolling cutters and the two shoes in front of each seed drill. The former pulverizes the clods, and the latter firms the soil in front of the drill. (From Cir. 295.)

Fig. 14.—Four-row lettuce planter in operation in the Salinas Valley. The beds were irrigated before seeding.

Very thick seeding is objectionable. The labor cost of thinning the thick stand of plants is expensive, and there is the additional waste of high-priced seed. From 1 to 1½ pounds of seed to the acre is sufficient if all the seed is viable and if the soil temperature and moisture conditions are favorable. Even under favorable conditions, however, the use of a little more seed may give a better stand.

The distance between rows should not be less than 10 inches. Some growers space the rows from 15 to 17 inches apart to give room for the development of large heads. When the rows are too close together on top of the bed, cultivation is more difficult, various diseases are likely to develop, and the mature heads are usually smaller. On the other hand, the plants usually grow better if not too near the edge of the bed.

If a large acreage is being grown, successive sowings should be made at intervals of 10 to 14 days throughout the lettuce-planting season. In some lettuce-growing projects, planting is continuous throughout the planting period, except when interrupted by adverse weather.

IRRIGATION AT PLANTING TIME

The system of irrigation used at the time of planting varies with the locality and with the climatic and soil conditions. In some regions the land is flood irrigated, the beds are made, the seed planted, and no further irrigation is given until the seedlings are through the soil. This system can be practiced where the soil dries out slowly. Beds of moist soil settle more evenly after irrigation than those made of loose, dry soil, so that preliminary flooding is advantageous.

Where evaporation is very high it is customary, in addition to the preliminary flood irrigation, to irrigate immediately after planting or as soon as germination is desired.

Rough beds are sometimes made in land that has not received a preliminary flooding. The beds are wet by running water in the furrows, as shown in figure 15. This irrigation moistens and settles the beds, which, when sufficiently dry, are smoothed and planted. This is the general practice in the Salinas-Watsonville district.

The fall crop of the interior valleys is usually planted in dry soil and then not irrigated until the grower desires to start the germination of the seed.

The following plan is sometimes used for the early plantings in the Imperial Valley: a preliminary flood irrigation is given, the beds

are made, and then irrigated. The tops of the beds, as soon as sufficiently dry, are harrowed with a special tool equipped with runners which slide in the furrows and prevent their being filled with clods.

Fig. 15.—Irrigating lettuce beds before seeding, in the Imperial Valley. Water enters the furrows from the head ditch through small conduits. Usually only one is used for each furrow. The piece of shook beside the opening is used to regulate the flow. (From Cir. 295.)

Fig. 16.—The seed has been planted, and the beds are being irrigated. Irrigation immediately after planting is an important operation in most of the lettuce-producing areas of California. (From Cir. 295.)

Seeding is started a few hours later, as soon as the soil is dry enough for the planter to operate. The land is irrigated again, as soon after seeding as possible.

In furrow irrigation, the water should be allowed to "sub" until it finally moistens the entire bed. Irrigating the beds immediately after planting, as shown in figures 16 and 17, is usually preferred in warm, dry weather. The water is often kept running in small streams down the furrows until the plants are up, in order to cool the soil and produce a high percentage of germination if the water is cooler than the soil. In cool weather such heavy irrigation immediately after planting is unnecessary. In heavy clay soils, deep furrows are used

Fig. 17.—Irrigation and drainage ditches. The drainage ditch at the right is carrying off the water which has passed down between the beds. The irrigation ditch at the left is ready to receive water and conduct it to the furrows between the beds. A more uniform control of moisture conditions can be obtained if the rows are not too long. Cross ditches for irrigating and drainage facilitate the equable distribution of water. (From Cir. 295.)

with a small head of water. If the water comes up close to the top of the bed, the soil will bake and crack when it dries, and the seedlings will not come through.

Regardless of location, however, the surface soil should be kept moist until after the seedlings are through the ground. In the hot interior valleys more care is needed to keep the surface soil moist than along the coast, where the moist air and cool temperatures prevent rapid evaporation. The time of irrigation depends mainly upon the size of the plant and upon the climatic and soil conditions.

THINNING AND HOEING

Lettuce should be thinned before the plants begin to crowd. In warm weather this time may be three weeks after planting, but in cool weather thinning may be delayed as long as eight weeks. The plants are blocked out 12 to 15 inches apart in the row with special short-handled hoes and at the same time are thinned by hand to one in a place, as shown in figures 18 and 19. Plants not true to type should be removed at this time. The plants should have plenty of room in the row.

Fig. 18.—Thinning lettuce in the Salinas Valley. Plants are spaced about 12 inches apart.

Thinning is a very important operation; and in many cases when it is done under contract, a part of the money is withheld until the job is finished in a satisfactory manner. Beds and furrows are usually cultivated before thinning. Growers often stipulate that all weeds left by the cultivator shall be removed by those doing the thinning, that the plants shall stand at a specified distance in the row, and that no doubles shall be allowed to remain (fig. 20). Many growers, however, have the weeds and doubles removed in a separate operation. When there is danger of damage by insects, thinning should be delayed, if possible, until the pests have been destroyed.

Fig. 19.—Thinning lettuce. Single plants are left at distances of about 12 inches. Blocking is done with a short-handled hoe. (From Cir. 295.)

Fig. 20.—An excellent stand of young lettuce for early fall harvest in the Salinas Valley. The plants have been thinned and the beds cultivated.

IRRIGATING THE GROWING CROP

The details of irrigation vary considerably in different localities and at different times of the year. Small plants need much less water than large ones. Less water is required when the weather is cool and humid than when it is hot, dry, and windy. The frequency of irrigation also depends on the water-holding capacity of the soil: as a rule, more frequent irrigations are needed on light, sandy soils than on silt or clay-loam soils, which are more retentive of moisture. Most growers believe that water should not be applied when the heads are maturing, since it has been observed that they are likely to be soft and loose. Heavy rains just before cutting time also may cause the development of open, spongy heads.

It takes some experience to know just when to irrigate, but as a rule the plants are in need of water when they become dark green and the leaves look and feel tough and leathery. When the moisture supply is plentiful, the leaves are crisp and are of a lighter green. During frosty weather, some growers practice night irrigation in the belief that the temperature of the air around the lettuce is raised.

Most growers use a series of wooden conduits or flumes to carry a small stream of water from the end ditch to the furrows between the beds. A conduit is made of four laths or slightly wider strips, such as cantaloupe shook, 20 to 24 inches long, nailed together. The conduit should be sufficiently long to fit well in the ditch bank. Pieces of shook or lath can be placed in front of the conduits to regulate the flow. Galvanized or iron pipes cut to the same length as the wooden conduits are often used. Iron lasts longer. Sizes from 1½ to 1¾ inches in diameter are generally used.

CULTIVATION

It is often desirable to cultivate in order to open the furrow and in order to replace the soil around the young plants after thinning (fig. 21). Later cultivations may be necessary to destroy weeds which rob the soil of moisture and soil nutrients but, beyond this point, cultivation is not necessary or even beneficial. Certain soil conditions, however, may require special consideration. The ordinary beet or bean cultivator gauged for either one or two beds is satisfactory. Power cultivators covering as much as three beds at a time are coming

into use. To insure close cultivation to the plant without injury, the grower must make the number of beds cultivated in a single operation correspond to the number of beds seeded at one time.

Fig. 21.—A four-row or two-bed cultivator in operation in the Salinas Valley. The number of rows cultivated corresponds to the number seeded at a single operation.

YIELD

According to the Federal and State Market News and Crop Reporting Service covering the past few years, production of lettuce for California has averaged slightly in excess of one-half carload for each acre seeded. A total crop failure because of insects, diseases, loose heads, or poor market conditions is not uncommon.

HARVESTING

Harvesting should not take place until the heads are hard. Growers show a tendency at times to harvest lettuce too soon, especially if the price is high. Most of them now realize, however, that money is usually lost by premature harvesting: immature heads wilt more readily, and not only sell for less but also ruin the market for the high-grade product. When ready to cut, the tops of the mature heads are lighter colored than those of the immature, and have a silvery appearance.

Lettuce should not be cut for shipment immediately after a rain or an irrigation, or before the frost and dew are gone in the morning.

Harvesting should, furthermore, not be done when the field is muddy. Then the plants are gorged with water, the leaves are crisp and brittle and break easily in handling; if just slightly wilted, they are injured less in handling and packing, and consequently will carry better in transit.

Fig. 22.—Harvesting lettuce, showing the type of knife used and the method of cutting off the root just below the ground. (From Cir. 295.)

Fig. 23.—Harvesting summer-grown lettuce in the Salinas Valley. The heads are cut and placed in rows. They are then packed in field crates for hauling to the lettuce-packing sheds.

Lettuce should be cut just below the surface of the ground, as is shown in figure 22. Most of the trimming of the outer leaves should be done at the packing shed.

Harvesting is usually done by contract labor. A gang of men go down the rows, cutting the matured heads and tossing them into the furrows (fig. 23). A second crew then pack the heads tightly into crates with the stems up; the crates are then loaded on trucks and hauled to the packing shed (fig. 24).

Lettuce heads that show signs of development of a seed stalk, that have burst, or that have tipburn, should be discarded in the field.

Fig. 24.—Loading field crates of lettuce for hauling to the packing shed.

Growers should not attempt to harvest all the heads in a field at one cutting. As a rule, one must make more than one cutting in order to obtain all heads at the best stage of maturity.

Lettuce should not be delivered to the packing shed in a badly wilted condition. When the haul to the packing shed is long, crates should be covered with heavy muslin or canvas. The crates in the field, furthermore, should not be filled too full, or the lettuce will be bruised and crushed.

In very warm weather or when freezes are expected, lettuce should be harvested as soon as it is hard. When the weather is cool, mature lettuce can remain in the field for some time without bursting. As a rule, however, it should not be held long at any time, if it is to be marketed in good condition and with a minimum of waste.

PACKING FOR SHIPMENT

At the packing shed, the loose, diseased, and damaged leaves are trimmed off, as shown in figure 25, and the small heads and loose heads are culled out. The tendency at present is to remove more of

Fig. 25.—Trimming lettuce. The butts and damaged or diseased leaves are trimmed off. The waste leaves are used for poultry, cattle, or hog feed. (From Cir. 295.)

the wrapper leaves than was formerly the practice. When trimmed, the heads are tossed to the packing table, where they are placed in the Standard California lettuce crate, as shown in figure 26. Twenty-

four, 30, 36, 42, 48, 60, 75, or 90 heads are put in each crate, depending upon their size. The growers and shippers, however, usually prefer to have heads that pack 4 and 5 dozen to the crate.

Fig. 26.—Packing and trimming in the packing shed. In the background the men are cutting back the stems and removing the diseased and damaged leaves. The trimmed heads are then tossed to a low table in reach of the packers. (From Cir. 295.)

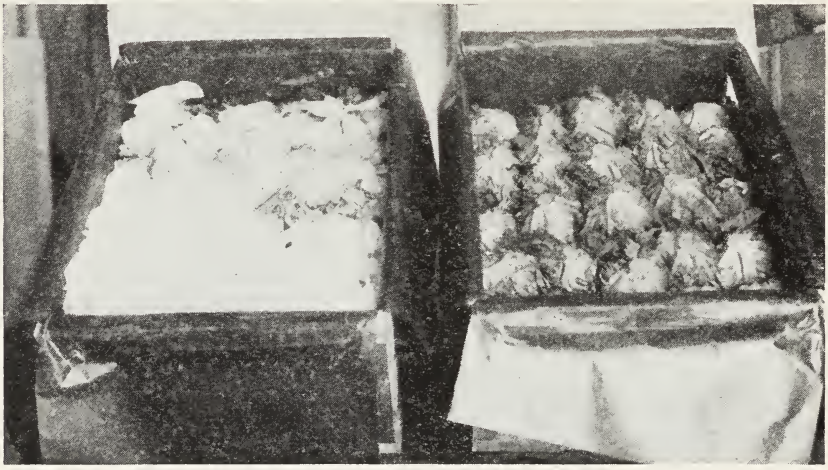

Fig. 27.—Cracked ice is placed between the layers of lettuce when packed. From 25 to 30 pounds of ice are used in each crate. This cools the lettuce and tends to insure its reaching the eastern markets in good condition. (From Cir. 295.)

The lettuce crate is lined with two strips of heavy waterproofed paper, which cover the bottom, sides, and ends, and fold over the top. This lining protects the heads from dirt and infection, keeps them

cool and fresh, and guards them against mechanical injury. Three layers of heads are packed tight in the crate with stems up, generally with cracked ice between the layers, as shown in figure 27. Usually not over 30 pounds of ice is used in each crate. The crates should be placed in the refrigerator car as soon as they are packed. From 4,500 to 7,500 pounds of ice, depending upon the weather, is placed in the car, usually on top of the crates (fig. 28) instead of in the bunkers. The use of ice on top of the load preserves the ice in the crates, thus keeping the lettuce fresh for a long time.

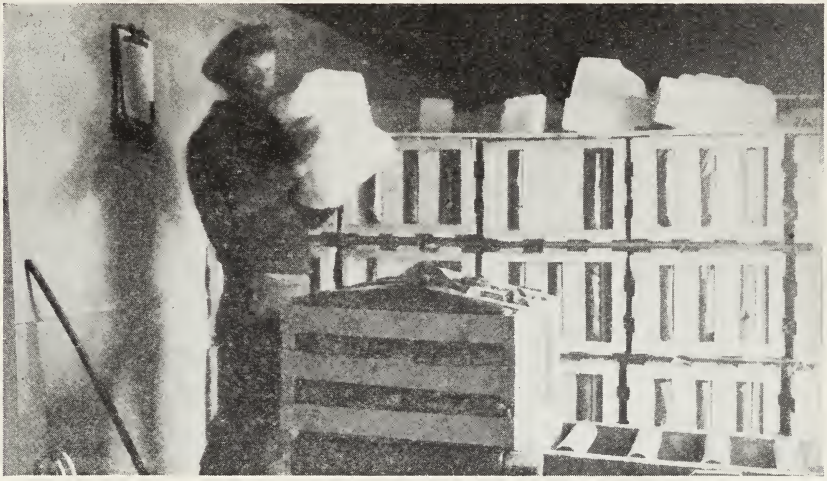

Fig. 28.—Loading car with lettuce. Crates are stacked 4 deep, 5 wide, and 16 long, and are held firm by wooden strips. Ice is placed on top of the upper tier of crates. The figure also shows a packed crate with the desirable bulge. (From Cir. 295.)

FEDERAL STANDARDS FOR HEAD LETTUCE

The U. S. Standard grades for lettuce formulated by the Bureau of Agricultural Economics, United States Department of Agriculture, as of December 1, 1926, are as follows:

"U. S. No. 1 shall consist of heads of lettuce of similar varietal characteristics which are fresh and well trimmed; which are not decayed, split or burst, and which are free from seed stems and doubles and from damage caused by dirt, wilting, freezing, tipburn, disease, insects, or mechanical or other means. The appearance of the wrapper leaves shall not be seriously affected from any cause. Not less than 75 per cent of the heads of Iceberg type lettuce shall be firm and the remainder shall be fairly firm. Heads of Big Boston type lettuce shall be fairly firm.

In order to allow for variations, incident to proper grading and handling, not more than 10 per cent by count, of any lot, may be soft or otherwise below

the requirements of this grade, but this tolerance shall not permit in any lot of Iceberg type lettuce fewer than 75 per cent of heads which are firm and free from defects not allowed in U. S. No. 1.

U. S. No. 2 shall consist of heads of lettuce of similar varietal characteristics which are fresh, which are not decayed, split, or burst, and which are free from seed stems and from damage caused by wilting, tipburn, disease, insects, or mechanical or other means and from serious damage caused by freezing.

In order to allow for variation incident to proper grading and handling, not more than 10 per cent, by count, of any lot may be below the requirements of this grade.

U. S. Fancy shall consist of heads of lettuce of similar varietal characteristics which are fresh and well trimmed, and which are not decayed, split or burst, and which are free from tipburn, seed stems, and doubles, and from damage caused by dirt, wilting, freezing, disease, insects, or mechanical or other means. The wrapper leaves shall be of a good green color and free from damage from any cause. Not less than 50 per cent of the heads of Iceberg type lettuce shall be hard and the remainder shall be firm. Heads of Big Boston type lettuce shall be firm.

In order to allow for variations incident to proper grading and handling not more than 10 per cent, by count, of any lot may be soft or otherwise below the requirements of this grade, but this tolerance shall not permit in any lot of the Iceberg type lettuce fewer than 50 per cent of heads which are hard and free from defects not allowed in U. S. Fancy.''

CALIFORNIA STANDARDS FOR HEAD LETTUCE

All head lettuce offered for sale in California must comply with the provisions as set forth in the *California Fruit, Nut and Vegetable Standardization Act of 1931.*

''*Section 32.*—Standard for head lettuce. Head lettuce shall not be leafy without head formation and shall be free from slime, decay or rot affecting leaves within the head, internal insect injury, and free from seed stems which have so developed that they are apparent upon external examination; and free from serious damage, as defined in this section caused by bursting or freezing. Damage caused by bursting shall not be considered serious unless the head is burst open or is materially misshapen from this cause. Damage caused by freezing shall not be considered serious unless it affects any portion of the head inside the six outer leaves.

In order to allow for variation incident to proper grading and handling, not more than 10 per cent by count, of the heads of lettuce in any one container or bulk lot may be below these requirements, but not to exceed one-half of this tolerance, or 5 per cent, shall be allowed for any one cause.

In addition to the other requirements specified in this section head lettuce, when packed, shall be virtually uniform in size which shall mean a variation in any container of not more than 10 per cent of heads which would pack a size, larger or smaller, than the size marked, and they shall be tightly packed which shall mean that it is not possible without damaging or injuring the lettuce, to place additional heads in any of the layers of heads in the container.

Head lettuce packed in ice shall be in standard container number 45, section thirty-eight to the contrary notwithstanding; however, other size containers may be used if conspicuously marked on the outside of the end which bears any marks intended to describe the contents of such container, in letters and numbers not less than one-half inch in height with the inside width in inches directly preceded by the word "width" and the inside length in inches, directly preceded by the word "length."

Section 38.—Head lettuce, when packed as a standard pack and so marked, must in addition to other packing requirements of the California Nut, Fruit and Vegetable Standardization Act of 1931, contain either two dozen, two and one-half dozen, three dozen, three and one-half dozen, four dozen, five dozen, seventy-five or ninety heads of lettuce per standard container number 45, with a slight bulge of crates when lidded. Each crate of three and one-half dozen count shall have each layer arranged with four rows of three, four, and four and three heads. In the case of sizes seventy-five and smaller per crate, a bridge of from three to six heads shall be permitted and in the five dozen size a bridge of four heads shall be permitted.

The standard lettuce crate number 45 has an inside depth of 13 inches, inside width of 18 inches, and an inside length of 21⅝ inches."

FEDERAL-STATE INSPECTION

The following brief synopsis of the history, function and scope of the Federal-State inspection service is taken from Special Publication 32 of the California State Department of Agriculture:

"In July, 1920, there was established in California a commercial shipping-point inspection service carried on by the Bureau of Standardization of the State Department of Agriculture. This service employs a corps of experienced, highly trained men who are authorized to inspect and certify to the exact quality and condition of the produce at time of packing and shipping. The demand for this service has increased steadily, and its scope and importance has been greatly enlarged . . . . On July 1, 1922, this service was federalized, each inspector being deputized by the federal government, and certificates are now prima facie evidence in all courts of the United States.

This inspection is available in all of the leading vegetable-producing sections of the state. The certificate shows the hour and date of inspection, inspection or shipping point, name and address of the shipper and consignee (when given), car initials and number, kind of car and its condition; if a refrigerator, the amount of ice in the bunkers; the quantity of the products inspected; description of load and container; condition of pack; sizing, quality, and condition of the product at the time the car is loaded, although he may be at a considerable distance from the shipping point. These shipping-point certificates are valuable to the grower, as they protect his interests in the adjustment of claims or on a declining market. On the other hand, the buyer is assured that he will receive the quality of produce for which he has paid before seeing it. Whenever requested, a telegram giving the substance of an inspection will be sent "collect" to the buyer or any other interested party, so that the exact condition of a carload can be ascertained before the sale is even consumated."

UTILIZATION OF CULL LETTUCE

In the process of packing, large quantities of leaves and cull heads accumulate. The leaves analyze 94.7 per cent water, 1.27 per cent protein, 0.3 per cent fat, 2.9 per cent carbohydrates, 0.7 per cent fiber, and 0.9 per cent ash. Although this material is usually dumped as waste, it has proved to be a fair feed for range cattle during the season of the year when there is a shortage of feed on the range. In August, September, and October of 1930, H. and N. Silacci, cattlemen of the Salinas Valley, fed 500 head of mixed range cattle entirely

Fig. 29.—Feeding beef cattle in the Salinas Valley on cull lettuce and leaves obtained from the packing sheds.

on cull lettuce (fig. 29). The animals made fair gains, and the only harmful effect noticed was that a few of them bloated; there were no losses. After about 70 days on this feed, 90 cows were sold for beef, these dressing out approximately 52 per cent. These 90 cows gained, according to an estimate, about 200 pounds per head during this period. Mature cows eat from 100 to 125 pounds of lettuce per day, when on full feed.

Cull lettuce is also being used successfully as a food for dairy cows. C. Higgins, a dairyman in the Salinas district, fed his cows for three months on cull lettuce supplemented with oat hay. The cows milked well on this ration and maintained fair condition. The butterfat content of the milk remained about the same as when the herd was fed on silage and oat hay.

Not only is lettuce a desirable feed for cattle, but it is also economical. The problem which confronts most cattlemen in feeding cull lettuce is to secure a continuous supply to carry their herd for a period of two or three months.

INSECT PESTS AND THEIR CONTROL

Cutworms.—Probably the most serious pest of lettuce is the cutworm, which usually cuts off the young plants at the ground level. The best control has been obtained by the use of poisoned bait. The following formula is recommended:

Paris green (or white arsenic)	1 pound
Molasses (cheap blackstrap)	2 quarts
Water	15 to 20 quarts
Dry bran	25 pounds

The poison should be thoroughly mixed with the bran. Each particle of bran must carry some poison in order to get a good kill. When making small quantities, one can mix the bait in a bucket with a paddle, adding the poison slowly and stirring in the bran at the same time. Or, the poison and bran can be mixed with the hands if the latter are free from cuts, scratches, or other wounds. When making large quantities, one can mix the poison with the bran on some flat, smooth surface, using a shovel and rake as in mixing concrete.

The syrup should be mixed with the water, then well stirred into the bran and poison mixture. Large quantities of liquid added at one time will wash the poison from the bran, resulting in an uneven mixture; only enough should be added to make a crumbly mash. A little of the mixture of dry bran and arsenic may well be set aside so that if too much liquid is added the dry reserve can be used to give the proper consistency.

This mash should be spread on top of the beds near the plants in the early evening, as cutworms do most of their feeding at night. Ten to fifteen pounds of the wet bait per acre is enough for one application. Two or three applications at two-day intervals may be needed to rid the field of the pest. When young, the plants may be dusted or sprayed with calcium arsenate, but not when approaching maturity.

Grasshoppers.—Grasshoppers sometimes eat entire fields of young fall-planted lettuce. Damage from them may be expected where lettuce fields are adjacent to alfalfa or pasture lands; these fields

should, if possible, be thoroughly disked or harrowed during the winter. Alfalfa land which is being broken up for lettuce, should be disked and harrowed before plowing, to destroy the eggs of grasshoppers and other insects and the pupal stages of cutworms. All growers, in addition, should make a regular practice of burning the grass and weeds, and working the ground along the roads and ditch banks adjoining their fields, for the grasshoppers lay their eggs in the surface of the soil of these untilled areas.

When grasshoppers appear in the field, a heavy irrigation should be given to moisten the ground thoroughly. The best means of control is to use the poison bran mash recommended for cutworms, with the addition of 18 chopped lemons and 1 pound of salt. The substitution of ½ pound of sodium arsenite for the paris green is also recommended. This mash should be spread in the early morning, because grasshoppers do most of their feeding during the day.

Alfalfa Semi-looper.—In the coastal districts, serious damage is often done by the alfalfa semi-looper (*Autographa californica*). Eggs are laid by the adult moth directly on the plant. In about ten days these hatch into green larvae that propel themselves by looping the body. In from four to six weeks the larvae attain their full size, three-fourths to one inch in length, and leave the plant to pupate in the soil. This insect is sometimes present in small numbers before thinning. After thinning, the larvae congregate on the remaining plants, often devouring all the foliage. The most serious injury is destruction of the terminal bud, which prevents the development of new leaves.

Unless the larvae are present in large numbers when the lettuce is heading, they usually cause only slight damage, because they leave the plant before it matures, so that the head develops normally. On mature plants injury is primarily from the dead tissue of the leaves, which makes the plant susceptible to slime rot.

Control of the semi-looper can be effected by spraying with a mixture made of 3 pounds of lead arsenate to 100 gallons of water, or by dusting with a 20 per cent lead arsenate, calcium arsenate, or zinc arsenite mixture at the rate of 30 pounds per acre. Barium fluosilicate, 6 pounds in 25 pounds of talc dust, has given excellent control and has an advantage over arsenical compounds in that it is not poisonous to human beings and can be used on much older plants without danger. Sodium fluosilicate is not recommended because under certain climatic conditions it is likely to cause burning. Poisonous dusts and sprays should not be applied after the lettuce heads are more than one-third developed.

Caterpillars.—Injury from caterpillars is usually confined to lettuce planted adjacent to alfalfa fields, ditch banks, or weed patches. The caterpillars hatch in these areas and when mature move into the lettuce field in search of a place to pupate, devouring plants in their path. Control by poisoning is difficult because of the maturity of the larvae. Barium fluosilicate, 30 per cent in talc, has at times given control. If abundant, caterpillars can be trapped in a trench dug with the steep side toward the lettuce.

Aphis.—Of the two species of aphis prevalent on lettuce, one is found on the leaves and the other on the roots. Both are somewhat similar in appearance. The leaf aphis, if abundant, checks the growth of the young plants by sucking out the juice. In the mature plants, the honeydew secretion deposited on the leaves by the aphis makes the lettuce unfit for market.

The root aphis is found clinging in cotton-like masses to the roots or in the adjacent soil. As the numbers increase the plants become yellowish and unhealthy in appearance. During the warm part of the day, they may wilt. Root aphis are more abundant in heavy soils that tend to crack and crumble than in the lighter, more sandy soils that remain compact.

New infestations of both the leaf and root aphis start from winged forms produced at certain stages of the life cycle. The female gives birth to living young in large numbers. If unchecked, the infestation may become general in the course of a few weeks.

Normally the leaf aphis is controlled by natural enemies. Predaceous insects such as the larvae of the common ladybird beetle and syrphid fly feed upon it. Some aphis are parasitized by insects and thus destroyed. Under warm, humid conditions certain fungi likewise tend to hold them in check. As a rule, serious outbreaks occur only during long periods of cloudy, damp, or foggy weather which make the natural enemies inactive.

The grower can control the leaf aphis by spraying with a nicotine solution made of one pint of Blackleaf 40 to 100 gallons of water, or by dusting with an 8 to 10 per cent nicotine dust. In the application of dust mixtures, the dragging of a canvas trailer 8 to 12 feet long behind the duster to confine the dust to the plant for a few seconds will be found advantageous. In both spraying and dusting, one must bring the material in direct contact with the insect. This procedure is often difficult, because most of the insects occur on the underside of the leaf.

The control of root aphis is extremely difficult because one cannot apply any material direct to the insect at a reasonable cost. Damage

can be held to a minimum by frequent irrigation given to keep the soil in an expanded condition and in close contact with the roots. An abundance of moisture also allows the unaffected roots to keep the plants in a good growing condition. Immediately after harvest, the grower should plow or cultivate the field to destroy all plants that might serve as a host to insects.

Wireworms.—Wireworms are the larvae of click beetles. They are yellowish-brown, segmented, and are from one-half to two inches long. During the spring and summer they are close to the surface of the soil and can be found feeding on a wide range of weeds and cultivated plants. They pass the winter months deep in the soil. They injure lettuce by burrowing and feeding in the taproot. If they find sufficient food during the spring months, they may go deep into the soil early in the year and not feed upon the fall crop.

The grower can control wireworms by attracting them with a trap crop or bait and then destroying them with poisonous gas. The field should be clean-cultivated and the soil well pulverized. The trap crop or bait, such as old peas and beans, is drilled into the soil about four inches deep; and the wireworms soon congregate about it. In five to eight days, granular calcium cyanide is drilled just over the bait at the rate of 75 to 100 pounds per acre. The moisture in the soil reacts with the calcium cyanide to form hydrocyanic acid gas which destroys the wireworms.

Vegetable Weevil.—The vegetable weevil (*Listroderes obliquus*) is not a pest in any of the main lettuce-shipping districts of California. It interests the lettuce grower only from the standpoint of certificates of weevil inspection that must accompany shipments within the state.

In California, the weevil is found only in a limited area, being confined to districts in the San Francisco Bay region.

The first adults of the vegetable weevil appear in March and feed on the tops of various vegetable plants until June, when they enter an aestivation period. They emerge from aestivation about September and begin their egg laying, which usually continues, with varying activity, until March and April. The larvae are present from October to April, feeding on the tops and crowns of most vegetables. The most destructive period is the winter, when the greatest number of larvae are present. When mature, they enter the soil and form pupae in small earthen cells, usually in the top soil. The adults emerge during the spring.

Corn Earworm.—In the coastal district, at certain seasons of the year, considerable damage is done to lettuce by the corn earworm (*Chloridea obsoleta*). The adult is a night-flying moth that emerges

from the soil in the late spring. Eggs are deposited on lettuce and other host plants. The eggs hatch in a few days and the young proceed to burrow into the host plant. In from 15 to 20 days the mature larvae leave the plant and enter the soil to pupate. The moth emerges in about 10 days to start a new generation. There are three or more broods during the year, the last probably doing the most damage to lettuce.

It is questionable if the corn earworm will multiply very rapidly on lettuce alone, as it is one of the least attractive host plants. However, if other host plants, such as corn and tomatoes, are present it will probably multiply rapidly.

Fig. 30.—Dusting lettuce in the early morning by airplane for the control of leaf-eating insects. (Courtesy, Britton Rey.)

Materials that have showed promise in the control of the corn earworm are zinc arsenite, and the fluosilicates. On the young beds a 20 per cent zinc arsenite dust is used while on the older beds the 25 per cent dust mixtures of fluosilicates are used. The dusts are applied at the rate of 35 pounds to the acre. It is necessary to have a covering on the plant almost continuously during the growing season because when once the insect penetrates the outer leaves it is impossible to obtain control. The airplane is coming into use as a means of spreading dusts for this and other leaf-eating insects. (fig. 30).

After harvesting, infested fields should be plowed to turn under the remaining plants. This will prevent the larvae in the heads from maturing. Disking of infested fields is not sufficient because if the heads are merely cut and allowed to dry the conditions within them are ideal for pupation.

BIRDS

In some sections of the state English sparrows often destroy many acres of young lettuce. Probably the best method of control is to place a large number of small scarecrows throughout the field in the form of bright pieces of cloth or paper fastened to laths or sticks. The use of a shotgun for a day or two will help to scare the birds away.

DISEASES AND THEIR CONTROL

Lettuce is no exception to the rule that with intensive propagation of one crop, one or several serious diseases gradually become epidemic. In California, four diseases have become serious within the past 18 years. Brown blight (cause unknown) has been present in Imperial Valley since 1912. Downy mildew (*Bremia lactucae*) occurs in Imperial Valley but is usually more prevalent in the coastal sections. Tipburn (actual cause unknown) occurs annually in most of the important lettuce districts and is thought to be induced by certain unfavorable climatic conditions. Slime (caused by *Botrytis* spp. and certain bacteria) usually attacks plants previously injured by tipburn. In addition to these four diseases, others of minor importance occur annually but do not usually cause heavy losses. Drop (*Sclerotinia* spp.), mosaic, and yellows have been found in California. Fortunately for lettuce growers, brown blight and mildew are now under control through the utilization of resistant strains, and some progress has been made with tipburn. Strains which resist tipburn are not likely to become slimy; hence slime control depends to a large extent upon the success in breeding tipburn-resistant strains.

Brown Blight.—Lettuce brown blight is known to occur only in California and Arizona. At present it is more prevalent in Imperial Valley than in the Salinas-Watsonville or the Santa Maria sections, but it is likely in time to become epidemic in the two latter districts also. Although the cause is as yet unknown, the inducing agent has been found able to persist in infested soil for long periods, even though nonsusceptible crops are grown. Occasionally the first lettuce crop on "new" land is slightly attacked, the disease gradually becoming more severe with succeeding lettuce crops (fig. 31). The disease has been thought to develop more rapidly in fine, silty, water-deposited soil types than in loamy soils. In some fields of the silt type in Imperial Valley, brown blight has made it impossible to grow more

than one or two lettuce crops, while in the Salinas-Watsonville district, five to ten profitable crops have been produced on loamy soils.

The disease may manifest itself at any time after the seedlings have developed five leaves, usually after thinning. Plants attacked when small assume a somewhat mottled, sickly yellow color, become rosetted, and never head. If attacked after heading, the entire plant may become yellowish; and dead, brown irregular streaks and blotches may develop in the outer leaves. Infected leaves usually dry up and turn brown.

Fig. 31.—Fields of lettuce showing increase in severity of brown blight as the number of lettuce crops grown successively on the same land increases. The field on the right shows from 75 to 100 per cent brown blight infection. Lettuce was grown in this field the two preceding years. The field on the left shows from 20 to 40 per cent brown blight infection. This field produced a lettuce crop the preceding year. (From Cir. 295.)

Although brown blight threatened to become so severe in Imperial Valley that lettuce could no longer be profitably grown, the disease is now under control through the efforts of Dr. Ivan C. Jagger of the United States Department of Agriculture. Dr. Jagger began his investigations in California in 1922 and has now distributed six brown blight-resistant strains which succeed on infested soil where other strains of New York are a total loss (fig. 32). The adaptability and resistance of these six strains (Imperial Nos. 2, 3, 6, and Imperial C, F, and D) are discussed elsewhere in this circular.

Downy Mildew.—In the coastal sections downy mildew (*Bremia lactucae*) is usually present every season; in Imperial Valley, only during an occasional season when there is an unusual amount of rain and dew. The disease also attacks endive, chicory, and certain weeds. Plants may be attacked at any stage of development, depending on certain environmental conditions, such as relatively low air temperature and periods of cloudy or rainy weather or heavy dews. Symptoms are evident on the leaves or seed stalk. On the leaves, yellowish or light green areas develop on the upper surface; the corresponding lower surface is usually covered by a dense, white or greyish, fluffy growth of the fungus which produces the spores capable of infecting

Fig. 32.—Comparison of brown blight-resistant and nonresistant lettuce. The two center rows are 100 per cent infected. The outer rows of resistant strains show normal growth.

other leaves. Infected spots may enlarge or several grow together until much of the leaf may be killed. Under California conditions, infected plants seldom die prematurely, but continue to grow more or less salable heads. Irregular white blotches may appear on infected seed stalks. When infected heads are shipped under refrigeration to distant markets, decay may follow mildew injury.

The causal organism is able to persist in the soil for a short time but will not withstand the freezing and thawing of winter in the North. Wild lettuce serves as a host in the "off season," enabling the organism to live over until lettuce is again planted. How long the organism is able to persist in the soil in either the Imperial Valley or the coastal districts is not definitely known.

Preventive measures include destruction of wild lettuce and other weed hosts and prompt removal or destruction of infected plants as

soon as the cutting season is over. Dr. Jagger has developed three resistant strains, Imperial C, D, and F, through hybridization and selection. In 1922 he crossed New York, a susceptible variety, with a resistant French variety of Romaine. These hybrids were then crossed with Imperial Nos. 2 and 3 in 1925, and continued selection resulted in the isolation of strains C, D, and F, which are resistant to both mildew and brown blight. These strains are further discussed elsewhere in this circular.

Tipburn.—Tipburn is a nonparasitic disease generally prevalent when warm, bright days follow periods of foggy or cloudy weather. It is characterized by dark brown discoloration near the margin of the upper, more tender, exposed leaves. The development of these small dead spots seems to prevent the passage of water to edges of the leaf; and that portion outside the spots becomes wilted and yellow and soon dies, leaving a dead, brown strip around the edge of the leaf. New York No. 12 is somewhat resistant, but not immune, to tipburn.

Slime.—Lettuce heads which have been subjected to tipburn in the field often develop a slimy soft rot or grey mold in the field or during transit and storage. This condition is caused by *Botrytis* and a number of different bacteria. Heads subjected to frost injury often develop slime. Infection usually starts on a protected, injured spot, from which the causal organisms may spread by means of water, wind, or insects to other plants. Sometimes the outer leaves tend to hide infected areas within the head. If injured leaves at the base of the plant are attacked, *Botrytis* often enters the stem, causing a rot at the soil surface; and the plant wilts.

Slime develops most rapidly during warm, damp periods; its development is checked by cold, dry weather. In the field, the control of slime usually resolves itself into prevention of tipburn. Strains resistant to tipburn are likewise less subject to slime. Where slime is a serious factor, plantings should be regulated so that the crop will mature in cool weather. Harvested heads showing any indication of slime should not be packed for long distance shipment, as slime is likely to spread during transit.

Yellows.—The nature and effects of lettuce yellows indicate that it is potentially a serious disease, although it has not caused appreciable loss in California to date. The disease is induced by a virus that is spread from diseased to healthy plants by the six-spotted leafhopper, *Cicadula sexnotata*, an insect extensively distributed in California. Infected leaves become yellowed and elongated; and the leaves of infected plants often turn outward instead of inward and

fail to head. Diseased plants had best be removed from the field and destroyed.

Big-veined Lettuce.—This disease has been observed in the Imperial Valley for a number of years. As the name indicates, the veins become large and coarse. While the lettuce usually heads, it is smaller than normal. Apparently this is a soil-borne disease as it persists year after year in the same ground. The acreage affected as yet is small, but is steadily increasing. The present strains of Imperial are susceptible to this disease but selections are now being made by Dr. Jagger for resistance.

Other Diseases.—Lettuce drop (*Sclerotinia minor* and *S. libertiana*), mosaic, and mottle leaf are known to occur in California but do not yet rank as serious diseases.

SHOOTING TO SEED PREMATURELY

Some loss is always caused by plants going to seed prematurely. This trouble usually results from unfavorable soil, moisture, and climatic conditions. It is difficult to determine in all cases just what the contributing factor or factors have been in bringing about this condition. The best lettuce seed available should be purchased; but, above all, growers should not attempt to grow lettuce under high temperature conditions, on steep slopes, or on light sandy or gravelly soils that are not retentive of moisture.

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